Clinical utility of $CHADS_2$ and CHA_2DS_2-VASc scoring systems for predicting postoperative atrial fibrillation after cardiac surgery

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Objectives: The presence of postoperative atrial fibrillation predicts a higher short- and long-term mortality rates; however, no scoring system has been used to discriminate patients at high risk for this complication. The aim of this study was to investigate whether the $CHADS_2$ and CHA_2DS_2-VASc scores are useful risk assessment tools for new-onset atrial fibrillation after cardiac surgery.

Methods: A total of 277 consecutive patients who underwent cardiac surgery were prospectively included in this risk stratification study. We calculated the $CHADS_2$ and CHA_2DS_2-VASc scores from the data collected. The primary end point was the development of postoperative atrial fibrillation within 30 days after cardiac surgery.

Results: Eighty-four (30%) of the patients had postoperative atrial fibrillation at a median of 2 days (range, 0-27 days) after cardiac surgery. The $CHADS_2$ and CHA_2DS_2-VASc scores were significant predictors of postoperative atrial fibrillation in separate multivariate regression analyses. The Kaplan-Meier analysis obtained a higher postoperative atrial fibrillation rate when based on the $CHADS_2$ and CHA_2DS_2-VASc scores of at least 2 than when based on scores less than 2 (both log rank, $P < .001$). In addition, the CHA_2DS_2-VASc scores could be used to further stratify the patients with $CHADS_2$ scores of 0 or 1 into 2 groups with different postoperative atrial fibrillation rates at a cutoff value of 2 (12% vs 32%; $P = .01$).

Conclusions: $CHADS_2$ and CHA_2DS_2-VASc scores were predictive of postoperative atrial fibrillation after cardiac surgery and may be helpful for identifying high-risk patients. (J Thorac Cardiovasc Surg 2013;146:919-26)

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Atrial fibrillation (AF) occurs in 205 to 40% of patients undergoing cardiac surgery, with the arrhythmia usually occurring between the second and fourth day after cardiac surgery.[1-3] Studies have demonstrated that various clinical risk factors, including advanced age, hypertension, left ventricular (LV) hypertrophy, LV systolic and diastolic dysfunction, and left atrial function and dimension, are closely linked to postoperative AF (POAF).[4-6] Although POAF is usually self-limiting, patients with POAF do tend to have longer hospital stays, increased perioperative morbidity, and greater early and long-term mortalites.[4-7]

It is advisable that prophylactic therapy with antiarrhythmic drugs be administered to decrease the incidence of POAF[8,9]; however, the use of prophylactic treatment in all patients to prevent POAF is not cost-effective.[2] In addition, such treatments may have adverse effects. Because the use of prophylactic therapy for all patients who undergo cardiac surgery is not reasonable, the identification of patients at risk for POAF would be helpful.

Use of the CHA_2DS_2-VASc score (congestive heart failure; hypertension; age $\geq$75 years [doubled]; type 2 diabetes; previous stroke, transient ischemic attack [TIA], or thromboembolism [doubled]; vascular disease; age 65-75 years; and sex category), which extends the $CHADS_2$ score (congestive heart failure, hypertension, age $\geq$75 years, type 2 diabetes, and previous stroke or TIA [doubled]) by considering additional stroke risk factors, was recently recommended to guide antithrombotic therapy in patients with AF or atrial flutter.[10-12] Each component of the $CHADS_2$ and CHA_2DS_2-VASc scores has been associated with the ventricular remodeling, LV diastolic function, and left atrial enlargement that may lead to atrial arrhythmia[13-15]; however, no published studies have investigated the association between the $CHADS_2$ and CHA_2DS_2-VASc scores in the prediction of POAF. This study aimed to assess the $CHADS_2$ and CHA_2DS_2-VASc scores for predicting the initiation of new-onset POAF after cardiac surgery.

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Abbreviations and Acronyms

AF = atrial fibrillation
CABG = coronary artery bypass grafting
CI = confidence interval
E = early mitral inflow velocity
e′ = medial mitral annular velocity during passive filling
LV = left ventricular
LVEDD = left ventricular end-diastolic diameter
LVM = left ventricular mass
OR = odds ratio
PAD = peripheral arterial disease
POAF = postoperative atrial fibrillation
PWTD = posterior wall thickness
SWTD = interventricular septal wall thickness
TIA = transient ischemic attack

MATERIALS AND METHODS

Patient Population

This prospective study recruited 340 consecutive patients who underwent cardiac surgery in our institution between January 2008 and December 2011. All had preoperative sinus rhythm and underwent isolated coronary artery bypass grafting (CABG), valvular repair or replacement, or both combined and survived the operation. We excluded patients with a preoperative history of AF, a pacemaker, Cox maze or radiofrequency ablation procedure for atrial arrhythmia, moderate or severe mitral stenosis or regurgitation, history of myocardial infarction in recent 3 months, or incomplete diastolic function assessment. A total of 280 patients met the inclusion criteria and were included in the study. After cardiac surgery, 3 patients who received early antiarrhythmic drugs for ventricular arrhythmia were excluded from the study. Finally, a total of 277 patients were enrolled in the study (mean age, 62.1 ± 9.7 years; 213 male).

Clinical reports, echocardiographic reports, carotid ultrasonography, and complete medical records were prospectively collected to investigate the relationship among $CHADS_2$, CHA_2DS_2-VASc score, and the risk of new-onset POAF after cardiac surgery. This study was approved by the institutional review board for human subjects at our institution, and the patients provided written, informed consent before participating in the study.

$CHADS_2$ and CHA_2DS_2-VASc Scores

The $CHADS_2$ score was calculated for all the patients by assigning 1 point for each of the following criteria: *c*ongestive heart failure, hypertension, age at least 75 years, and diabetes mellitus. A further 2 points was added for the criterion of previous *s*troke or TIA. In contrast, the CHA_2DS_2-VASc score is based on a point system in which 2 points each are assigned for age at least 75 years and for history of *s*troke, TIA, or thromboembolism and 1 point is assigned for each of the following criteria: congestive heart failure, hypertension, diabetes mellitus, age 65 to 75 years, vascular disease (defined as previous myocardial infarction, complex aortic plaque, carotid disease, and peripheral arterial disease [PAD], including intermittent claudication, previous surgery or percutaneous intervention on the abdominal aorta or the lower extremity vessels, and arterial and venous thrombosis), and female sex category.[10,11] The cutoff values of the $CHADS_2$ and CHA_2DS_2-VASc scores used for grouping were determined according to risk of stroke and atrial properties determined in earlier studies.[11,16,17]

POAF Definition

The study defined POAF in the same manner as earlier studies that defined POAF on the basis of documented AF episodes lasting longer than 30 seconds recorded by continuous telemetry throughout hospitalization or by electrocardiography within the 30-day follow-up period after cardiac surgery.[5,18] A standard 12-lead electrocardiogram was recorded for every patient who had a suspected arrhythmic event.

Echocardiography

Echocardiography was performed by an experienced sonographer (S.K.C.) before the index cardiac procedure. Doppler echocardiography was performed to determine the early mitral inflow velocity (E), and a tissue Doppler imaging evaluation was performed to determine the medial mitral annular velocity during passive filling (e′).[19,20] Diastolic dysfunction was defined as an E/e′ ratio greater than 15, as previously described elsewhere.[20] LV size and wall thickness were determined with M-mode measurement. The diastolic measurements of LV end-diastolic diameter (LVEDD), interventricular septal wall thickness (SWTD), and posterior wall thickness (PWTD, all in millimeters) were used to calculate LV mass (LVM) in grams according to the formula recommended by the American Society of Echocardiography[21]:

$$\mathrm{LVM} = 0.8\left\{1.04\left[(\mathrm{LVEDD} + \mathrm{SWTD} + \mathrm{PWTD})^3 - (\mathrm{LVEDD})^3\right]\right\} + 0.6$$

The LVM index (in grams per square meter) was defined as LVM normalized by body surface area.[21]

Carotid Ultrasonography

The diagnosis of carotid artery stenosis was based on the ultrasonographic analysis, and all carotid ultrasonographic studies were performed before cardiac surgery. The method of carotid artery stenosis measurement has been reported previously.[22] In brief, the equipment used was a SONOS 5500 ultrasound system (Philips Healthcare, Andover, Mass) equipped with a 3- to 11-MHz real-time B-mode scanner and a 3.6-MHz pulsed Doppler mode scanner. Carotid artery segments, including the common carotid artery, internal carotid artery, and external carotid artery, were measured bilaterally by an experienced neurologist (L.M.L.) who was blinded to each subject's information. The presence of plaques was defined as localized echo structures encroaching into the arterial lumen of at least 50% of the surrounding intimal media thickness value. The presence of significant carotid artery stenosis was defined as a large plaque comprising at least 50% of the diameter of the carotid artery stenosis.

Statistics

In this study, we enrolled around 100 patients with risk scale scores of at least 2 and 170 subjects with scores lower than 2. Our preliminary data indicated that the POAF rate among those with low score would be 20%. If the true relative risk of subjects with high scores relative to those with low scores were 2, we would be able to reject the null hypothesis that the relative risk was equal to 1 with probability (power) of 0.8. The type I error probability associated with this test of this null hypothesis is 0.05.

Quantitative data are expressed as mean ± SD and were compared with 2-sample *t* tests for independent samples. Differences in proportion were compared with a χ^2 test or Fisher exact test as appropriate. Univariate association of variables with the outcome of POAF within 30 days was assessed with multivariate logistic regression. For each variable, the odds ratio (OR), 95% confidence interval (CI), and *P* value are provided. Exploratory data analyses were conducted with univariate summaries to examine distributions of key variables. Variables significantly associated with POAF after univariate analysis ($P < .05$) and those that were established risk factors were entered in a multivariable logistic regression model to identify the independent predictors of POAF. The POAF-free survival curves were constructed according to the Kaplan–Meier method. The

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TABLE 1. Baseline characteristics of patients with and without postoperative atrial fibrillation

	With POAF (n = 84)	Without POAF (n = 193)	*P* value
Age (y)	66.7 ± 9.1	60.2 ± 9.3	<.001
Age ≥65 y	53 (63.1%)	62 (33.0%)	<.001
Age ≥75 y	22 (26.2%)	14 (7.3%)	<.001
Male	64 (76.2%)	149 (77.2%)	.86
Body mass index (kg/m^2)	25.8 ± 3.9	26.1 ± 3.8	.61
Current smoking	41 (48.8%)	81 (42.0%)	.29
Medical history			
Hypertension	71 (84.5%)	142 (73.6%)	.047
Diabetes mellitus	52 (61.9%)	101 (52.3%)	.14
Congestive heart failure	25 (29.8%)	42 (21.8%)	.13
Previous stroke or TIA	19 (22.6%)	19 (9.8%)	.004
Hyperlipidemia	38 (45.2)	108 (56.0%)	.10
Vascular disease*	39 (45.9%)	45 (23.4%)	<.001
Previous myocardial infarction	13 (15.5%)	12 (6.2%)	.01
Carotid artery stenosis†	17 (20.2%)	30 (15.5%)	.32
Peripheral arterial disease	10 (11.9%)	5 (2.6%)	<.001
Preoperative medication			
β-Blockers	38 (64%)	161 (74%)	.15
ACEIs or ARBs	35 (59%)	132 (61%)	.87
Calcium channel blockers	16 (19%)	36 (19%)	.94
Statin therapies	28 (47%)	124 (57%)	.20
Diuretics	30 (36%)	54 (28%)	.20
Aspirin	46 (55%)	111 (58%)	.67
Clopidogrel	50 (60%)	110 (57%)	.70
Laboratory data			
Glycosylated hemoglobin (%)	5.8% ± 1.8%	6.1% ± 2.0%	.32
Total cholesterol (mg/dL)	184 ± 37	182 ± 43	.63
Triglycerides (mg/dL)	210 ± 142	202 ± 140	.70
High-density lipoprotein (mg/dL)	43 ± 16	39 ± 12	.08
Low-density lipoprotein (mg/dL)	104 ± 32	112 ± 37	.14
Echocardiographic features			
Left atrial diameter (mm)	41.3 ± 6.9	39.2 ± 6.1	.014
LVEDD (mm)	52.1 ± 7.4	51.5 ± 8.0	.60
LVM (g)	205.6 ± 59.3	202.3 ± 75.3	.72
LVM index (g/m^2)	119.4 ± 34.8	112.4 ± 38.4	.17
E/e′ ratio	20.3 ± 7.3	11.9 ± 13.8	.002
Diastolic dysfunction‡	40 (47.6%)	65 (33.7%)	.03
LVEF (%)	58.1% ± 13.6%	59.1% ± 14.2%	.58
LVEF <40%	8 (9.5%)	22 (11.4%)	.60
$CHADS_2$ score	2.5 ± 1.4	1.7 ± 1.1	<.001
CHA_2DS_2-VASc score	3.8 ± 1.7	2.5 ± 1.5	<.001

Data are presented as n (%) or mean ± SD. *POAF*, Postoperative atrial fibrillation; *TIA*, transient ischemic attack; *ACEI*, angiotensin-converting enzyme inhibitor; *ARB*, angiotensin receptor blockers; *LVEDD*, left ventricular end-diastolic diameter; *LVM*, left ventricular mass; *E*, passive transmitral left ventricular inflow velocity; *e′*, tissue Doppler imaging velocity of the medial mitral annulus during passive filling; *LVEF*, left ventricular ejection fraction. *Vascular disease was defined as previous myocardial infarction, carotid artery stenosis, or peripheral arterial disease, including previous revascularization, amputation for peripheral arterial disease, or angiographic evidence of peripheral arterial disease. †Carotid artery stenosis was defined as moderate to severe carotid artery stenosis. ‡Diastolic dysfunction was defined as E/e′ ratio >15.

significance of the difference between the curves was assessed by the log-rank test.

RESULTS

Clinical Characteristics and Predictors of POAF

The study population had a mean age of 62 years (range, 38-84 years) and comprised 213 men (77%) and 64 women (23%). Of the 277 study patients, 213 (79%) had hypertension, 153 (55%) had diabetes mellitus, 67 (24%) had a history of congestive heart failure, and 38 (14%) had a history of stroke or TIA. A total of 85 patients (31%) had vascular disease, including 25 with a history of myocardial infarction, 47 with carotid artery stenosis, and 15 with PAD.

The baseline clinical characteristics of patients with and without POAF are summarized in Table 1. Of the 277 study patients, 84 (30%) had POAF at a median of 2 days (range, 0-27 days) after cardiac surgery. The patients with POAF were older and had a significantly higher prevalence of

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hypertension and stroke or TIA and vascular disease, including previous myocardial infarction and PAD, than the patients without POAF. The echocardiographic findings of the patients with POAF included larger left atrial dimension, higher E/e′ ratio, and higher frequency of E/e′ greater than 15 than did those obtained for patients without POAF. There were no significant differences in LVEDD, LVM, LVM index, and LV ejection fraction between patients with and without POAF. The patients with POAF had higher $CHADS_2$ scores (2.5 ± 1.4 vs 1.7 ± 1.1; $P < .001$) and CHA_2DS_2-VASc scores (3.8 ± 1.7 vs 2.5 ± 1.5; $P < .001$) than did those without POAF.

Surgical data and postoperative complications are presented in Table E1. Among a total of 277 study patients, isolated CABG surgery was performed in 258 (93.1%), aortic valve surgery in 15 (5.4%), tricuspid valve surgery in 1 (0.4%), and combined CABG and valve procedures in 3 (1.1%). The incidences of POAF in the isolated CABG group and single-valve group were 80 (31.0%) and 4 (25.0%), respectively ($P = .61$). There were no significant differences between patients with and without POAF in surgical procure type, rate of on- or off-pump surgery, duration of bypass or operation, and number of grafts used. In addition, there were no significant differences in rate of postoperative complications between patients with and without POAF.

Significant predictors of POAF according to univariate regression analysis are shown in Table 2. $CHADS_2$ score (OR, 1.62; 95% CI, 1.30-2.02; $P < .001$), CHA_2DS_2-VASc score (OR, 1.67; 95% CI, 1.40-2.01; $P < .001$), left atrial diameter (OR, 1.05; 95% CI, 1.01-1.10; $P = .02$), and E/e′ ratio (OR, 1.10; 95% CI 1.03-1.17; $P = .002$) were significantly associated with POAF. According to the separate multivariate logistic regression analysis, after adjustment for echocardiographic risk factors, the $CHADS_2$ (OR, 1.54; 95% CI, 1.21-1.94; $P < .001$) and CHA_2DS_2-VASc scores (OR, 1.63; 95% CI, 1.35-1.96; $P < .001$) remained independent predictors of POAF (Table 3).

TABLE 2. Univariate regression analysis for postoperative atrial fibrillation predictors

Variable	Odds ratio	95% CI	*P* value
$CHADS_2$ score	1.62	1.30-2.02	<.001
CHA_2DS_2-VASc score	1.68	1.40-2.01	<.001
ACEIs or ARBs	1.18	0.70-2.01	.52
β-Blockers	0.82	0.47-1.44	.50
Statin therapy	0.75	0.45-1.26	.28
Left atrial diameter (mm)	1.05	1.01-1.10	.02
LVMI (g/m^2)	1.005	0.99-1.01	.17
E/e′ ratio	1.10	1.03-1.17	.002
LVEF (%)	0.99	0.98-1.01	.58

CI, Confidence interval; *ACEI*, angiotensin-converting enzyme inhibitor; *ARB*, angiotensin receptor blocker; *LVMI*, left ventricular mass index; *E*, passive transmitral left ventricular inflow velocity; *e′*, tissue Doppler imaging velocity of the medial mitral annulus during passive filling; *LVEF*, left ventricular ejection fraction.

TABLE 3. Multivariate logistic regression analysis for postoperative atrial fibrillation predictors with $CHADS_2$ or CHA_2DS_2-VASc score

Variable	Odds ratio	95% CI	*P* value
With $CHADS_2$ score			
Left atrial diameter (mm)	1.02	0.97-1.07	.49
LVMI (g/m^2)	1.003	0.99-1.01	.54
E/e′ ratio	1.34	0.76-2.37	.31
LVEF (%)	0.99	0.98-1.02	.87
$CHADS_2$ score	1.54	1.21-1.94	<.001
With CHA_2DS_2-VASc score			
Left atrial diameter (mm)	1.01	0.96-1.06	.59
LVMI (g/m^2)	1.002	0.99-1.01	.61
E/e′ ratio	1.42	0.79-2.53	.24
LVEF (%)	0.99	0.98-1.02	.73
CHA_2DS_2-VASc score	1.63	1.35-1.96	<.001

CI, Confidence interval; *LVMI*, left ventricular mass index; *E*, passive transmitral left ventricular inflow velocity; *e′*, tissue Doppler imaging velocity of the medial mitral annulus during passive filling; *LVEF*, left ventricular ejection fraction.

$CHADS_2$ and CHA_2DS_2-VASc Scores for Predicting POAF

The POAF rates after cardiac surgery continuously increased with increasing $CHADS_2$ and CHA_2DS_2-VASc scores (Figure 1). Figure E1 shows the OR for predicting POAF after cardiac surgery on the basis of the $CHADS_2$ and CHA_2DS_2-VASc scores. The increased POAF risk after cardiac surgery was magnified with increasing $CHADS_2$ and CHA_2DS_2-VASc scores.

At the cutoff point of 2, the Kaplan-Meier survival analysis revealed that patients with $CHADS_2$ scores of at least 2 had a higher POAF rate than did the patients with $CHADS_2$ scores less than 2 (36% vs 20%; $P = .005$; Figure 2, *A*). Furthermore, a CHA_2DS_2-VASc score of at least 2 also significantly predicted the occurrence of events (35% vs 13%; $P = .001$; Figure 2, *B*).

CHA_2DS_2-VASc Scores and POAF in Patients With $CHADS_2$ Scores of 0 or 1

The subgroup analysis of the 103 patients with $CHADS_2$ scores of 0 or 1 revealed that 21 of these patients (20%) had POAF. The POAF rate progressively increased from 6% in patients with CHA_2DS_2-VASc scores of 0 to 44% in patients with CHA_2DS_2-VASc scores of 3 ($P = .03$; Figure 3, *A*). When a CHA_2DS_2-VASc score of 2 was used as the cutoff point, the patients with scores of at least 2 were associated with a higher event rate than seen among the patients with CHA_2DS_2-VASc scores less than 2 (32% vs 12%; $P = .01$; Figure 3, *B*).

Relationship Between $CHADS_2$ or CHA_2DS_2-VASc Scores and LV Diastolic Function

The relationship between $CHADS_2$ or CHA_2DS_2-VASc scores and LV systolic and diastolic function is summarized in Table E2. The patients with $CHADS_2$ or CHA_2DS_2-VASc

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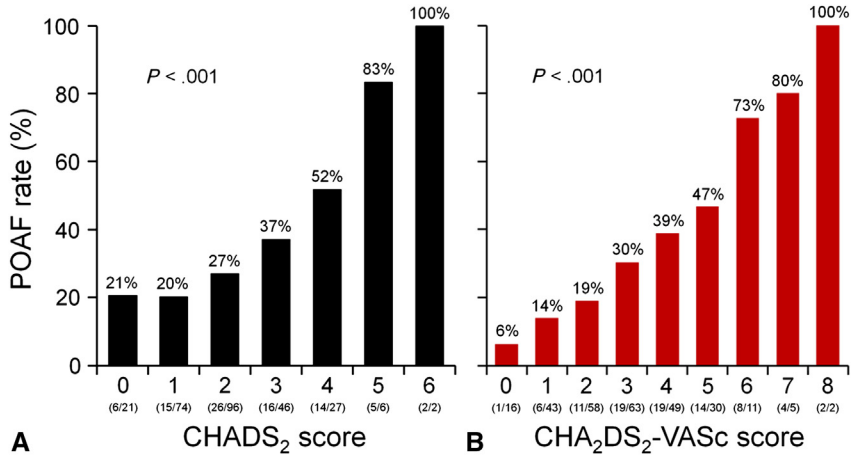

FIGURE 1. Postoperative atrial fibrillation (*POAF*) rates and scores. The POAF rates continuously increased as the $CHADS_2$ (A) and CHA_2DS_2-VASc (B) scores increased.

scores of at least 2 had a larger LA diameter, a higher E/e′ ratio, and a higher rate of E/e′ greater than 15 than did those with scores less than 2; however, no significant differences in LVEDD and LV ejection fraction were seen between these groups.

DISCUSSION

Major Findings

This study included a cohort of patients who underwent cardiac surgery and demonstrated that $CHADS_2$ and CHA_2DS_2-VASc scores could be helpful and convenient scoring systems for predicting POAF after cardiac surgery. The $CHAD_2DS_2$-VASc score was useful in further risk stratifications for POAF among patients with $CHADS_2$ scores of 0 or 1.

Incidence of New-Onset POAF After Cardiac Surgery

Similar to the results of earlier studies, the incidence of POAF in this study was 30% at a median of 2 days (range, 0-27 days) after cardiac surgery.[1,2]

$CHADS_2$ and CHA_2DS_2-VASc Scores and POAF After Cardiac Surgery

To date, several demographic and preoperative factors such as age, sex, hypertension, diabetes mellitus, and LV systolic and diastolic function have been shown to be risk factors for POAF[4,6]; however, no published classification scheme has included these risk factors to estimate the risk of POAF in patients who undergo cardiac surgery. With different multivariate models, our study demonstrated that

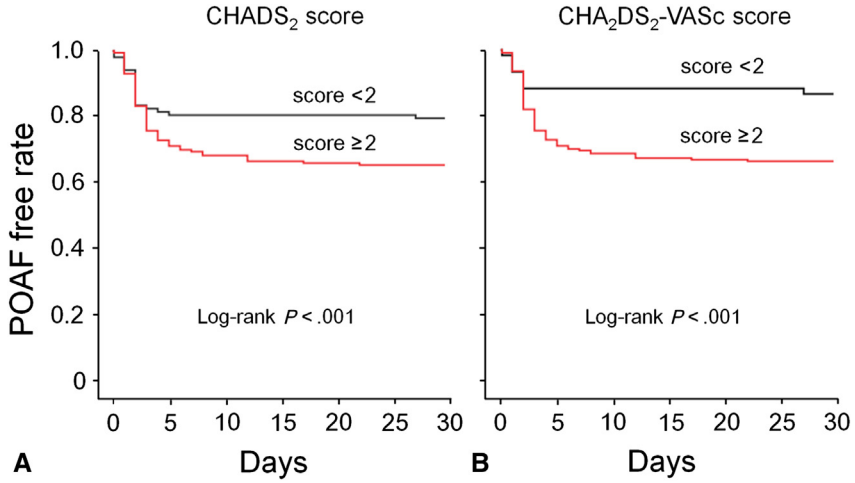

FIGURE 2. Postoperative atrial fibrillation (*POAF*)-free rate curves for patients with higher and lower $CHADS_2$ and CHA_2DS_2-VASc scores. The Kaplan-Meier survival analysis showed that the patients with $CHADS_2$ scores of at least 2 had a higher event rate than did the patients with $CHADS_2$ scores lower than 2 (log-rank, $P < .001$; A). In addition, a CHA_2DS_2-VASc score of at least 2 also significantly predicted occurrences of postoperative atrial fibrillation (log-rank, $P < .001$; B).

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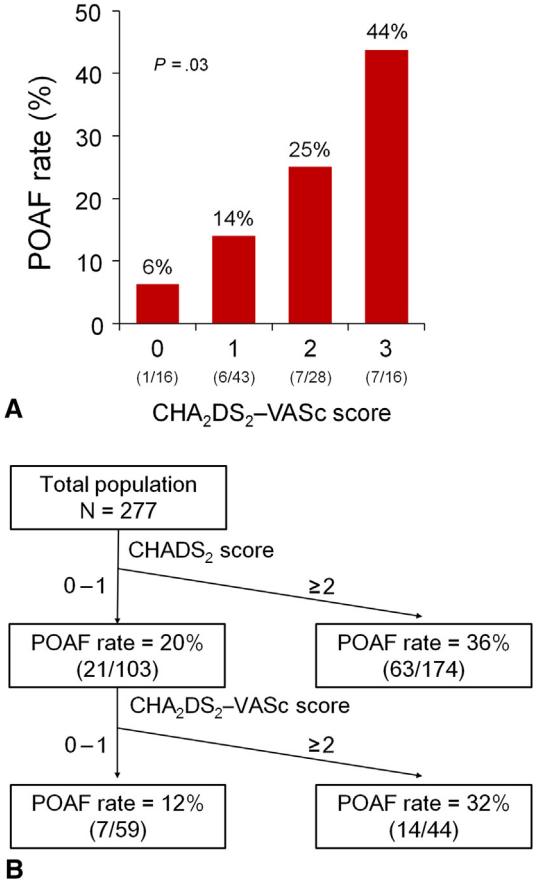

FIGURE 3. A, Postoperative atrial fibrillation (*POAF*) rates in the patients with $CHADS_2$ scores of 0 or 1. Postoperative atrial fibrillation rates progressively increased from 6% to 44% with increasing CHA_2DS_2-VASc score. B, Flowchart of postoperative atrial fibrillation rates and scores. This flowchart demonstrates the postoperative atrial fibrillation rates in the patients stratified according to $CHADS_2$ and CHA_2DS_2-VASc scores.

the $CHADS_2$ scores are powerful predictors of POAF after cardiac surgery. These finding extend the usefulness of $CHADS_2$ scores to the prediction of POAF in patients undergoing cardiac surgery. Physicians and patients could use these scores to make decisions about prophylactic therapy according to patient-specific POAF risk.

In our study, POAF rates increased with increasing CHA_2DS_2-VASc score, whereas patients with scores of 0 to 1 had low POAF rates. The CHA_2DS_2-VASc score could further stratify the patients with $CHADS_2$ scores of 0 or 1 into 2 groups with different POAF risks at the cutoff value of 2. There is some justification for the addition of female sex, vascular disease, and age 65 to 74 years into the combination risk factor category in the CHA_2DS_2-VASc score. The impact of female sex on atrial arrhythmia has recently been reviewed.[23,24] In all age groups, men have a higher incidence of AF than do women. Because the incidence of AF increases with age and there are more women in the population who are older than 65 years, the absolute numbers of female and male patients with AF in this age group are equal.[23,24]

The impact of vascular disease, particularly myocardial infarction, on increasing AF risk has also been systematically reviewed. AF often complicates myocardial infarction, with an incidence of 6% to 21%. Furthermore, the presence of AF in association with PAD is associated with substantial mortality and morbidity.[25] Because age does not have a binary effect on AF and an age of at least 75 years is a high risk factor, an age of 65 to 74 years plus an additional combination risk factor increases risk of AF.[23] Taken together, the risk of new-onset AF after cardiac surgery might increase with the combination of these additional risk factors in the CHA_2DS_2-VASc score.

Potential Mechanisms Responsible for the Association Between Increased $CHADS_2$ or CHA_2DS_2-VASc Scores and POAF

Because it is well established that atrial dilatation and stretch increase atrial vulnerability to the occurrence of AF, it has been reported that increasing LV diastolic dysfunction is strongly correlated with left atrial enlargement.[26] An incremental deterioration of diastolic function is associated with increased left atrial dimension and provides further predictive information with regard to the occurrence of POAF.[5,26,27] Each component of the $CHADS_2$ and CHA_2DS_2-VASc scores was associated with ventricular remodeling and LV diastolic function that may lead to left atrial enlargement.[13,14] In addition, this study also found that patients with $CHADS_2$ and CHA_2DS_2-VASc scores of at least 2 had worse LV diastolic function than did those with scores lower than 2. These findings suggest that advanced $CHADS_2$ and CHA_2DS_2-VASc score amplifies the POAF risk after cardiac surgery and that these changes are mediated by stress on the atria in the context of impaired LV diastolic function to increase the risk of POAF.

Clinical Implications

Several studies have demonstrated that interventions to prevent POAF consisting of β-blockers, amiodarone, or statins are favored with respect to clinical outcome[8,9]; however, these studies did not provide a useful scoring system to discriminate patients at a high risk for POAF. According to this study, the $CHADS_2$ scoring system is a simple tool that can predict new-onset POAF after cardiac surgery. A $CHADS_2$ score of at least 2 was associated with a 36% risk of POAF. Furthermore, the more detailed CHA_2DS_2-VASc scoring system can further discriminate patients at risk for POAF among patients with $CHADS_2$ scores of 0 or 1. The clinical implication of CHA_2DS_2-VASc scores should be emphasized, because patients with $CHADS_2$ scores of 0 or 1 have traditionally been assumed to be at low risk; however, those with CHA_2DS_2-VASc

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scores of 3 can have a POAF rate as high as 44%. These findings demonstrate the important role of the CHA_2DS_2-VASc scores in discriminating supposedly low-risk patients who are at risk for POAF and optimizing preoperative management of antiarrhythmic therapy before cardiac surgery is prescribed to lower the risk. A further large-scale, prospective trial is necessary to prove this supposition.

Study Limitations

There are several limitations to the interpretation of our study. The incidence of POAF may be different among patients undergoing CABG and valve procedures, and thus the application of the scoring system to a nonhomogeneous group of patients may have biased the results. Most of the study patients underwent isolated CABG or a single-valve operation, however, and only a few proportionately of them underwent both CABG and valve surgery. Previous studies as well as our own have shown that the incidence of POAF does not differ significantly between patients undergoing isolated CABG and those undergoing single-valve procedures.[5]

The patients were not monitored with a continuous recording system for 30 days after cardiac surgery. It is therefore possible that short arrhythmic episodes were missed. In addition, any participants with paroxysmal or asymptomatic AF were missed if such episodes occurred outside of the hospital. The incidence of POAF in this study thus may be underestimated, which would have biased the results and worked against the significant association among $CHADS_2$ and CHA_2DS_2-VASc scores and POAF. Our findings resemble those of earlier studies, however, in that the peak incidence of POAF was between postoperative days 2 and 4.[4,5]

CONCLUSIONS

$CHADS_2$ and CHA_2DS_2-VASc scores can provide an estimate of the POAF risk in patients who undergo cardiac surgery. Among patients with $CHADS_2$ scores of 0 or 1, CHA_2DS_2-VASc scores were helpful to discriminate further which patients were predisposed toward increased POAF risk.

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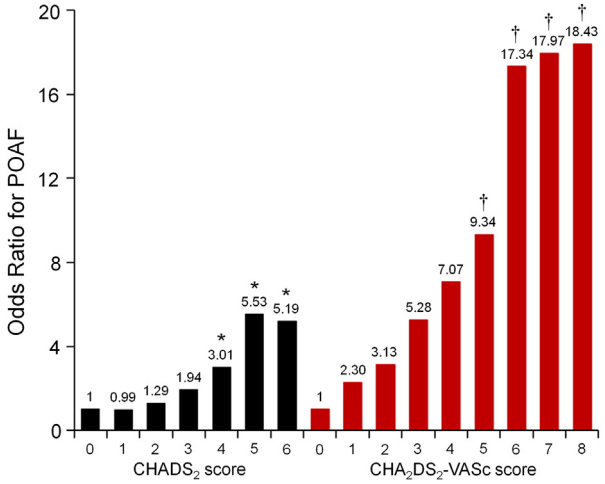

FIGURE E1. Adjusted odds ratios of $CHADS_2$ or CHA_2DS_2-VASc scores for predicting postoperative atrial fibrillation after cardiac surgery. The patients with increased $CHADS_2$ or CHA_2DS_2-VASc scores face a progressively increasing risk of postoperative atrial fibrillation with each subsequent increment in score. The odds ratio is defined as the likelihood of postoperative atrial fibrillation after cardiac surgery compared with scores of 0. *$P < .05$ compared with $CHADS_2$ score of 0. †$P < .05$ compared with CHA_2DS_2-VASc score of 0.

TABLE E1. Surgical procedure and postoperative complications of patients with and without postoperative atrial fibrillation

	With POAF (n = 84)	Without POAF (n = 193)	*P* value
Surgical procedure			.59
Isolated CABG	80 (95.2%)	178 (92.2%)	
Aortic valve procedures	4 (4.8%)	11 (5.7%)	
Tricuspid valve procedures	0 (0%)	1 (0.5%)	
Combined CABG and valve surgery	0 (0%)	3 (1.6%)	
Bypass surgery			.80
On-pump surgery	57 (67.9%)	1301 (67.9%)	
Off-pump surgery	27 (32.%1)	62 (32.1%)	
Duration of bypass (min)	123 ± 65	124 ± 62	.89
Duration of operation (min)	300 ± 125	307 ± 107	.64
Grafts used			.65
1	6 (7.1%)	7 (3.6%)	
2	8 (9.5%)	18 (9.3%)	
3	65 (77.4%)	156 (80.8%)	
Postoperative complications			
Poor wound healing requiring reconstruction	6 (7.1%)	6 (3.2%)	.15
Stroke	4 (4.8%)	5 (2.7%)	.38
Sepsis	2 (2.4%)	3 (1.6%)	.67
Massive gastrointestinal bleeding	2 (2.4%)	3 (1.6%)	.67
Myocardial infarction	1 (1.2%)	1 (0.5%)	.57
Acute renal failure requiring hemodialysis	1 (1.2%)	1 (0.5%)	.57

Data are presented as n (%) or mean ± SD. *POAF*, Postoperative atrial fibrillation; *CABG*, coronary artery bypass grafting.

TABLE E2. Echocardiographic features of the different $CHADS_2$ and CHA_2DS_2-VASc scores (<2 and ≥2)

	<2	≥2	*P* value
$CHADS_2$ score			
Left atrial diameter (mm)	38.3 ± 6.3	40.7 ± 6.3	.002
LVEDD (mm)	50.8 ± 7.8	52.2 ± 7.8	.15
LVM (g)	197.6 ± 77.5	209.4 ± 71.2	.21
LVM index (g/m^2)	110.8 ± 43.7	122.8 ± 45.3	.04
E/e′ ratio	10.1 ± 8.2	21.6 ± 11.6	<.001
E/e′ ratio >15	28 (27%)	77 (44%)	.005
LVEF (%)	60.5% ± 12.3%	57.2% ± 14.7%	.08
CHA_2DS_2-VASc score			
Left atrial diameter (mm)	38.3 ± 5.7	40.3 ± 6.5	.04
LVEDD (mm)	50.1 ± 7.4	52.1 ± 7.9	.08
LVM (g)	187.2 ± 63.7	209.8 ± 75.5	.04
LVM index (g/m^2)	103.2 ± 36.3	122.6 ± 46.3	.004
E/e′ ratio	10.0 ± 7.2	18.8 ± 12.2	.003
E/e′ ratio >15	15 (25%)	90 (41%)	.026
LVEF (%)	61.2% ± 12.0%	58.2% ± 14.5%	.15

LVEDD, Left ventricular end diastolic diameter; *LVM*, left ventricular mass; *E*, passive transmitral left ventricular inflow velocity; *e′*, tissue Doppler imaging velocity of the medial mitral annulus during passive filling; *LVEF*, left ventricular ejection fraction.

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